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(71)Applicant KURITA WATER IND LTD

:

(72)Inventor : KOBATA KENJI

IIMURA AKIRA

USUI REI

SATO SHIGERU

/A

## (54) SCALE INHIBITOR

## (57)Abstract:

PROBLEM TO BE SOLVED: To demonstrate a large effect in preventing adhesion of various kinds of scales, especially silicate type scale, generated in a cooling water system, a boiler water system, and others by incorporating a water soluble polymer having silanol group units given by a specified formula.

SOLUTION: A scale preventing agent contains a water soluble polymer having silanol group units given by the formula (wherein R1 and R2 are each hydrogen or a 1-3C alkyl group). The content of the silanol group unit in the polymer is not particularly restricted; however, the content based on the total monomer units in the polymer is preferably 0.1-10 mol.%. When the content is below 0.1 mol.%, an enough scale preventive effect can hardly be demonstrated. When it exceeds 10 mol.%, the effect does not increase with the increase in the content to cause economical disadvantage and decrease in the solubility of the polymer in water.

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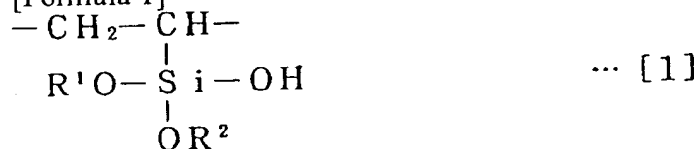
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## CLAIMS

[Claim(s)]

[Claim 1] The scale inhibitor characterized by containing the water-soluble polymer which has the silanol-group unit expressed with a general formula [1].

[Formula 1]



(However, R1 and R2 are hydrogen or the alkyl group of carbon numbers 1-3 among a formula.)

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## DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] this invention relates to a scale inhibitor. Still in

detail, this invention can prevent effectively scales, such as a cooling water system and the boiler water system, and relates to a scale inhibitor effective in prevention of a silicic-acid system scale especially.

[0002]

[Description of the Prior Art] Scale failure occurs within the heating surface in contact with water, such as a cooling water system and the boiler water system, and piping. When exclusion (blow) out of the system of cooling water is lessened and high concentration operation is especially performed from saving resources and the position of energy saving in an open closed cooling water system, while the salts dissolved in cooling water are condensed and it becomes easy to corrode the heating surface, the salt of poor solubility separates and scale-izes. The generated scale causes a serious failure for operation of a boiler, a heat exchanger, etc. for a fall of thermal efficiency, lock out of piping, etc. As a scale kind generated to a drainage system, there are a calcium carbonate, a calcium sulfate, a calcium sulfite, calcium phosphate, a calcium silicate, a magnesium silicate, a magnesium hydroxide, phosphoric-acid zinc, zinc hydroxide, a basic zinc carbonate, etc. Generally to the calcium system or the magnesium system scale, the copolymer which combined the monomer in which the polymer which has the carboxyl group which carried out the polymerization of a maleic acid, an acrylic acid, the itaconic acid, etc. has sulfonic groups, such as a monomer which is effective as a scale inhibitor and has a carboxyl group further, a vinyl sulfonic acid and an allyl-compound sulfonic acid, and a 2-acrylamide-isobutane sulfonic acid, is used as a scale inhibitor according to object water quality. Moreover, to the silicic-acid system scale, the scale inhibitor (JP,2-31894,A) containing the scale inhibitor (JP,61-107998,A) and polyethylene glycol containing an acrylamide system polymer and an acrylic-acid system polymer, a \*\*\*\*\* acid or its salt, and/or a carboxylic-acid system polymer etc. is proposed, and these scale inhibitors are properly used according to the scale kind. Since the water used in a cooling water system is usually industrial water, city water, etc., underwater, various ion kinds are dissolved. Therefore, when performing especially high concentration operation, the scale inhibitor which can correspond to all scale kinds effectively is desirable. However, in the present condition, the scale inhibitor effective for scale prevention of all scale kinds in this way is not yet found out. The scale inhibitor which has an effect remarkable in silicic-acid system scale-buildup prevention especially is not developed. For example, although the scale prevention effect accepts when silicic-acid concentration is low, an acrylamide system polymer is deficient in an effect, when silicic-acid concentration is high. The metal in systems, such as piping, is easy to adsorb, and since tabescence of a polymer is remarkable, a cation system polymer is lacking in practicality. Moreover, although the effect of suppressing a scale buildup accepts when silicic-acid concentration is low, a polyethylene glycol tends to be influenced of the ion of other type, and has the problem of an effect not being stabilized.

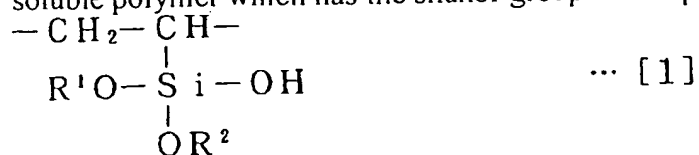
[0003]

[Problem(s) to be Solved by the Invention] The effect of this invention is large to the various scale-buildup prevention generated by the cooling water system, the boiler water system, etc., and it is made for the purpose of offering the scale inhibitor which demonstrates the effect which was especially excellent to silicic-acid system scale-buildup prevention.

[0004]

[Means for Solving the Problem] The water-soluble polymer which has a silanol group finds out excelling in the scale prevention effect, especially the prevention effect of a silicic-acid system scale, and this invention persons came to complete this invention based on this knowledge, as a

result of repeating a research zealously that the above-mentioned technical problem should be solved. That is, this invention is a scale inhibitor [-izing 2] characterized by containing the water-soluble polymer which has the silanol-group unit expressed with a general formula [1].

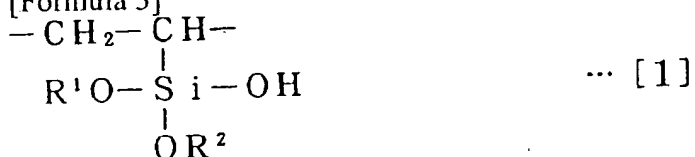


R1 and R2 are hydrogen or the alkyl group of carbon numbers 1-3 among (however a formula.) is offered.

[0005]

[Embodiments of the Invention] The scale inhibitor of this invention contains the water-soluble polymer which has the silanol-group unit expressed with a general formula [1].

[Formula 3]



In a general formula [1], R1 and R2 are hydrogen or the alkyl group of carbon numbers 1-3. the water-soluble polymerization used for this invention -- although there is especially no limit in the amount of a silanol-group unit in the living body -- usually -- a silanol-group unit -- a polymerization -- it is desirable that it is [ 0.1-10 mol / of all monomeric units in the living body ] %, it is more desirable that it is / 0.5-7 mol / %, and it is still desirable that it is / 1-5 mol / % When the amount of a silanol-group unit is less than [ of all the monomeric units in a polymer / 0.1 mol % ], there is a possibility that the scale prevention effect may not fully be demonstrated. When the amount of a silanol-group unit exceeds ten mol% of all the monomeric units in a polymer, a possibility that it may not improve if the increase in a silanol-group unit is balanced, but a manufacture of a polymer may become disadvantageous economically, and the water solubility of a polymer may fall has the scale prevention effect.

[0006] Although there is especially no limit in the molecular weight of the water-soluble polymer which has the silanol-group unit used for this invention, usually, it is desirable that it is 500-100,000 as weight average molecular weight, it is more desirable that it is 3,000-70,000, and it is still desirable that it is 10,000-50,000. When the weight average molecular weight of a water-soluble polymer is less than 500, there is a possibility that the scale prevention effect may not fully be demonstrated. When the weight average molecular weight of a water-soluble polymer exceeds 100,000, there is a possibility that the viscosity of the aqueous solution of a polymer may become high too much, and handling may become difficult. The molecular weight of a polymer can be calculated by the gel permeation chromatography, the light scattering measurement, etc. The monomer which has the base which especially a limit does not have in the manufacture technique of a water-soluble polymer of having the silanol-group unit used for this invention, for example, turns into a silanol group by hydrolysis, The monomer which has the base which can manufacture by understanding the obtained copolymer an added water part after copolymerizing the monomer which has the base which turns into a hydrophilic radical by hydrolysis, and turns into a silanol group by hydrolysis, After copolymerizing the monomer which has a hydrophilic radical, it can manufacture by carrying out copolymerization of the monomer which can manufacture by understanding the obtained copolymer an added water part,

or has a silanol group, and the monomer which has a hydrophilic radical.

[0007] As a monomer which has the base which turns into a silanol group by hydrolysis, vinyltrimetoxysilane, vinyltriethoxysilane, \*\*\*\*\* propoxysilane, vinyl \*\*\*\*\* propoxysilane, a vinyl tris (2-methoxyethoxy) silane, etc. can be mentioned, for example. These monomers can be manufactured by the addition reaction of trialkoxysilane and acetylene, or the reaction of a vinyl trichlorosilane and alcohol. As a monomer which has the base which turns into a hydrophilic radical by hydrolysis, acrylonitrile (meta), methyl (meta) acrylate, ethyl (meta) acrylate, vinyl acetate, a maleic anhydride, N-alkyl (meta) acrylamide, etc. can be mentioned, for example. As a monomer which has a hydrophilic radical, an acrylic acid (meta), a maleic acid, an itaconic acid, a vinyl sulfonic acid, an allyl-compound sulfonic acid, a 2-acrylamide-isobutane sulfonic acid, a 3-ant \*\*\*\*\*-2-hydroxy propane sulfonic acid, a styrene sulfonic acid, isoprene sulfonic acids or these alkali-metal salts, hydroxyethyl (meta) acrylate, \*\*\*\*\* monoallyl ether, allyl alcohol, an acrylamide (meta), N-vinyl pyrrolidone, etc. can be mentioned, for example. The water-soluble polymer used for this invention is the domain which does not lose the water solubility, and can have a hydrophobic monomeric unit. As such a hydrophobic monomer, styrene, N-vinylcarbazole, etc. can be mentioned, for example.

[0008] The monomer which has the monomer or silanol group which has the base which turns into a silanol group by hydrolysis used for this invention, There is especially no limit in the copolymerization technique with the monomer which has the monomer or hydrophilic radical which has the base which turns into a hydrophilic radical by hydrolysis, and if all monomers and copolymers obtained are water-soluble The solution polymerization through water can be performed, and if the copolymer obtained with the monomer of all or a part is water-insoluble nature, the emulsion polymerization or suspension polymerization through water, and the solution polymerization through an organic solvent can be performed. The copolymer of the monomer which has the base which turns into a hydrophilic radical by the monomer or hydrolysis which has the base which turns into a silanol group by hydrolysis is changed into the water-soluble polymer which has the silanol group and hydrophilic radical which are expressed with a general formula [1] by hydrolysis. There is especially no limit in the hydrolysis technique, and it can understand an added water part in an aqueous medium preferably using an acid, alkali, etc. With [ the carbon number of an alkoxy group ] three [ or less ], let the copolymer of vinyl trialkoxysilane be the silanol-group unit shown by the general formula [1] by understanding 1 of three alkoxy groups, two pieces, or three pieces an added water part. Moreover, with [ the carbon number of an alkoxy group ] four [ or more ], in a general formula [1], it can consider as the silanol-group unit R1 and whose R2 are hydrogen by understanding all alkoxy groups an added water part. When the monomer which has the base which turns into a hydrophilic radical by hydrolysis is vinyl acetate, a vinyl acetate unit is changed per vinyl alcohol by hydrolysis, and a polymer becomes water-soluble. [0009] The scale inhibitor of this invention can be used with respect to water quality conditions and \*\*\*\*\*s, such as a cooling water system and the boiler water system, that there is nothing. The scale inhibitor of this invention can be added and used for circulating water or make up water in a cooling water system, the boiler water system, etc. There is especially no limit in the location and the addition technique of adding the scale inhibitor of this invention, and it can be added in arbitrary parts as aqueous solution prepared to arbitrary concentration in the drainage system to use to them. Although the addition of the scale inhibitor of this invention can be suitably chosen according to the water quality of the drainage system to add, the service condition of a facility, etc., it is desirable to add so that underwater concentration may usually become 1. in 1-200mg /, and it is more desirable to add so that it may

become l. in 10-50mg /. The scale inhibitor of this invention can be used together with other scale inhibitors, anticorrosives, a germicide, a slime inhibitor, etc. if needed. When using the scale inhibitor of this invention together with other medicines, the medicine of \*\*\*\*\* can be mixed beforehand, and it can consider as a l liquid type, or each can be added separately. While adhesion in the heating surface and the piping wall surface of scales, such as a calcium carbonate, a calcium sulfate, calcium phosphate, phosphoric-acid zinc, zinc hydroxide, a magnesium silicate, and a silica, which occur in a cooling water system, the boiler water system, etc. can be prevented by the scale inhibitor of this invention, the scale which already adhered is also removable. Especially the scale inhibitor of this invention demonstrates the effect excellent in scale-buildup prevention of a silicic-acid system. Although the detailed mechanism of action of the scale inhibitor of this invention is unknown, it is thought by combining with the colloidal silica which is the scale formation factor which a polymer generates by the drainage system through a silanol group that the adhesion to the system wall of a silicic-acid system scale etc. is prevented effectively.

[0010]

[Example] Although an example is given to below and this invention is explained to it still in detail, this invention is not limited at all by these examples. The scale inhibitor and scaling test method which were used for the example and the example of a comparison are shown below.

[Scale inhibitor]

(A) The vinyl silanol / vinyl alcohol copolymer, molecular weight 15,000 which were obtained by understanding a copolymer (vinyltrimetoxysilane 2 mol % and 98 mols % of vinyl acetate) an added water part.

(B) The vinyl silanol / vinyl alcohol / allyl alcohol copolymer, molecular weight 15,000 which were obtained by understanding the 88 mols copolymer (% and allyl alcohol 10 mol %) of vinyl acetate an added water part vinyltrimetoxysilane 2 mol%.

(C) The vinyl silanol / vinyl alcohol / styrene copolymer, molecular weight 15,000 which were obtained by understanding the 90 mols copolymer (% and styrene 5 mol %) of vinyl acetate an added water part vinyltrimetoxysilane 5 mol%.

(D) A copolymer (80 mols % of acrylic acids, and 20 mols % of 3-ant \*\*\*\*\*-2-hydroxy propane sulfonic acids), molecular weight 9,000.

the possession in which a [scaling test-method] heating surface has the heat exchanger of 2 about 0.25m -- 0.45m of amount of water, the water which added salts was added to the pure water or the Atsugi city water as circulating water and make up water at the open circulating model cooling water system of 3, and it ran continuously for 30 days, controlling blow water so that a concentration multiple becomes 5 times The quality of the material used for the heat exchanger the tube whose outer diameter is 19mm by SUS304. The heat exchanger inlet temperature of circulating water adjusted 45 degrees C and heat exchanger outlet temperature to 75 degrees C, - and the rate of flow in the tube side of circulating water was carried out in 0.5m/s. In the meantime, the specified quantity of a scale inhibitor was added to the drainage system. After 30 day continuous running, the scale adhering to the heat exchanger tube front face was extracted. Weighing capacity of this scale was carried out, and the scaling speed was computed from the coating weight. Moreover, the chemical analysis of this scale was carried out, and SiO<sub>2</sub> amount in a scale was calculated.

It examined by adding a scale inhibitor (A) so that it may become [ l. ] in 20mg /in the water which has water quality with silica 200mg/a l. [ an example 1pH /9.0 /, a calcium hardness of 0mg /l. /, 0mg /l. / M alkalinity, ], and a magnesium degree of hardness of 200mg [l. ]. Scaling

speeds will be 8mg/[cm]<sup>2</sup>/30 days, and SiO<sub>2</sub> was not contained in the scale.

In the same water of water quality as example 2 example 1, it examined by adding a scale inhibitor (B) so that it may become [ 1. ] in 20mg /. Scaling speeds will be 10mg/[cm]<sup>2</sup>/30 days, and SiO<sub>2</sub> was not contained in the scale.

In the same water of water quality as example 3 example 1, it examined by adding a scale inhibitor (C) so that it may become [ 1. ] in 20mg /. Scaling speeds were 11mg/[cm]<sup>2</sup>/30 days, and SiO<sub>2</sub> amount in a scale was 1 % of the weight.

In the same water of water quality as example of comparison 1 example 1, it examined by adding a scale inhibitor (D) so that it may become [ 1. ] in 20mg /. Scaling speeds were 111mg/[cm]<sup>2</sup>/30 days, and SiO<sub>2</sub> amount in a scale was 45 % of the weight. The result of the examples 1-3 and the example 1 of a comparison is shown in the 1st table.

[0011]

[Table 1]

第1表

	スケール防止剤	添加量 (mg/リットル)	スケール付着速度 (mg/cm <sup>2</sup> /30日)	スケール中のSiO <sub>2</sub> 量 (重量%)
実施例1	(A)	20	8	0
実施例2	(B)	20	10	0
実施例3	(C)	20	11	1
比較例1	(D)	20	111	45

[0012] In the examples 1-3 which added the scale inhibitor of this invention, a scaling speed is small, there are very few SiO<sub>2</sub> amounts in a scale, the scale inhibitor of this invention has the large scaling prevention effect, and the result of the 1st table shows excelling especially in the antisticking of SiO<sub>2</sub>. On the other hand, in the example 1 of a comparison which added the conventional scale inhibitor, a scaling speed is large and there are also many amounts of SiO<sub>2</sub> in a scale.

It examined by adding a scale inhibitor (A) so that it may become [ 1. ] in 20mg /in the water which has water quality with silica 200mg/a l. [ an example 4pH /9.0 /, a calcium hardness of 500mg /l. /, 500mg /l. / M alkalinity, ], and a magnesium degree of hardness of 200mg [l. ]. Scaling speeds will be 8mg/[cm]<sup>2</sup>/30 days, and SiO<sub>2</sub> was not contained in the scale.

In the same water of water quality as example 5 example 4, it examined by adding a scale inhibitor (B) so that it may become [ 1. ] in 20mg /. Scaling speeds were 8mg/[cm]<sup>2</sup>/30 days, and SiO<sub>2</sub> amount in a scale was 1 % of the weight.

In the same water of water quality as example 6 example 4, it examined by adding a scale inhibitor (C) so that it may become [ 1. ] in 20mg /. Scaling speeds were 14mg/[cm]<sup>2</sup>/30 days, and SiO<sub>2</sub> amount in a scale was 1 % of the weight.

In the same water of water quality as example of comparison 2 example 4, it examined by adding a scale inhibitor (D) so that it may become [ 1. ] in 20mg /. Scaling speeds were 124mg/[cm]<sup>2</sup>/30 days, and SiO<sub>2</sub> amount in a scale was 52 % of the weight.

In the same water of water quality as example of comparison 3 example 4, it examined by adding a scale inhibitor (D) so that it may become [ 1. ] in 40mg /. Scaling speeds were 119mg/[cm]<sup>2</sup>/30 days, and SiO<sub>2</sub> amount in a scale was 47 % of the weight. The result of the examples 4-6 and the examples 2-3 of a comparison is shown in the 2nd table.

[0013]

[Table 2]  
第2表

	スケール防止剤	添加量 (mg/リットル)	スケール付着速度 (mg/cm <sup>2</sup> /30日)	スケール中のSiO <sub>2</sub> 量 (重量%)
実施例4	(A)	20	8	0
実施例5	(B)	20	8	1
実施例6	(C)	20	14	1
比較例2	(D)	20	124	52
比較例3	(D)	40	119	47

[0014] In the examples 4-6 which added the scale inhibitor of this invention, a scaling speed is small, there are few SiO<sub>2</sub> amounts in a scale, the scale inhibitor of this invention has the large scaling prevention effect, and the result of the 2nd table shows excelling especially in the antisticking of SiO<sub>2</sub>. On the other hand, in the example 2 of a comparison which added the conventional scale inhibitor, a scaling speed is large and there are also many amounts of SiO<sub>2</sub> in a scale. Furthermore, in the example 3 of a comparison, although the addition of the same conventional scale inhibitor as the example 2 of a comparison is doubled, the enhancement in the scale prevention effect is very slight.

[0015]

[Effect of the Invention] The scale inhibitor of this invention shows the effect excellent in scale-buildup prevention compared with the conventional scale inhibitor. Especially the scale inhibitor of this invention is effective in silicic-acid system scale-buildup prevention.

## Field

[The technical field to which invention belongs] this invention relates to a scale inhibitor. Still in detail, this invention can prevent effectively scales, such as a cooling water system and the boiler water system, and relates to a scale inhibitor effective in prevention of a silicic-acid system scale especially.

## Technique

[Description of the Prior Art] Scale failure occurs within the heating surface in contact with water, such as a cooling water system and the boiler water system, and piping. When exclusion (blow) out of the system of cooling water is lessened and high concentration operation is especially performed from saving resources and the position of energy saving in an open closed cooling water system, while the salts dissolved in cooling water are condensed and it becomes easy to corrode the heating surface, the salt of poor solubility separates and scale-izes. The generated scale causes a serious failure for operation of a boiler, a heat exchanger, etc. for a fall of thermal efficiency, lock out of piping, etc. As a scale kind generated to a drainage system, there are a calcium carbonate, a calcium sulfate, a calcium sulfite, calcium phosphate, a calcium silicate, a magnesium silicate, a magnesium hydroxide, phosphoric-acid zinc, zinc hydroxide, a basic zinc carbonate, etc. Generally to the calcium system or the magnesium system scale, the copolymer which combined the monomer in which the polymer which has the carboxyl group

which carried out the polymerization of a maleic acid, an acrylic acid, the itaconic acid, etc. has sulfonic groups, such as a monomer which is effective as a scale inhibitor and has a carboxyl group further, a vinyl sulfonic acid and an allyl-compound sulfonic acid, and a 2-acrylamide-isobutane sulfonic acid, is used as a scale inhibitor according to object water quality. Moreover, to the silicic-acid system scale, the scale inhibitor (JP,2-31894,A) containing the scale inhibitor (JP,61-107998,A) and polyethylene glycol containing an acrylamide system polymer and an acrylic-acid system polymer, a \*\*\*\*\* acid or its salt, and/or a carboxylic-acid system polymer etc. is proposed, and these scale inhibitors are properly used according to the scale kind. Since the water used in a cooling water system is usually industrial water, city water, etc., underwater, various ion kinds are dissolved. Therefore, when performing especially high concentration operation, the scale inhibitor which can correspond to all scale kinds effectively is desirable. However, in the present condition, the scale inhibitor effective for scale prevention of all scale kinds in this way is not yet found out. The scale inhibitor which has an effect remarkable in silicic-acid system scale-buildup prevention especially is not developed. For example, although the scale prevention effect accepts when silicic-acid concentration is low, an acrylamide system polymer is deficient in an effect, when silicic-acid concentration is high. The metal in systems, such as piping, is easy to adsorb, and since tabescence of a polymer is remarkable, a cation system polymer is lacking in practicality. Moreover, although the effect of suppressing a scale buildup accepts when silicic-acid concentration is low, a polyethylene glycol tends to be influenced of the ion of other type, and has the problem of an effect not being stabilized.

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#### Effect

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[Effect of the Invention] The scale inhibitor of this invention shows the effect excellent in scale-buildup prevention compared with the conventional scale inhibitor. Especially the scale inhibitor of this invention is effective in silicic-acid system scale-buildup prevention.

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#### TECHNICAL PROBLEM

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[Problem(s) to be Solved by the Invention] The effect of this invention is large to the various scale-buildup prevention generated by the cooling water system, the boiler water system, etc., and it is made for the purpose of offering the scale inhibitor which demonstrates the effect which was especially excellent to silicic-acid system scale-buildup prevention.

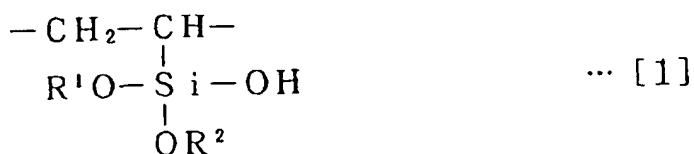
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#### MEANS

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[Means for Solving the Problem] The water-soluble polymer which has a silanol group finds out excelling in the scale prevention effect, especially the prevention effect of a silicic-acid system scale, and this invention persons came to complete this invention based on this knowledge, as a result of repeating a research zealously that the above-mentioned technical problem should be solved. That is, this invention is a scale inhibitor [-izing 2] characterized by containing the water-soluble polymer which has the silanol-group unit expressed with a general formula [1].

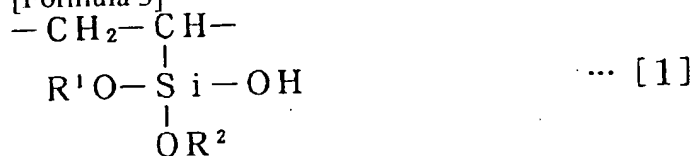


R1 and R2 are hydrogen or the alkyl group of carbon numbers 1-3 among (however a formula.) is offered.

[0005]

[Embodiments of the Invention] The scale inhibitor of this invention contains the water-soluble polymer which has the silanol-group unit expressed with a general formula [1].

[Formula 3]



In a general formula [1], R1 and R2 are hydrogen or the alkyl group of carbon numbers 1-3. the water-soluble polymerization used for this invention -- although there is especially no limit in the amount of a silanol-group unit in the living body -- usually -- a silanol-group unit -- a polymerization -- it is desirable that it is [ 0.1-10 mol / of all monomeric units in the living body ] %, it is more desirable that it is / 0.5-7 mol / %, and it is still desirable that it is / 1-5 mol / % When the amount of a silanol-group unit is less than [ of all the monomeric units in a polymer / 0.1 mol % ], there is a possibility that the scale prevention effect may not fully be demonstrated. When the amount of a silanol-group unit exceeds ten mol% of all the monomeric units in a polymer, a possibility that it may not improve if the increase in a silanol-group unit is balanced, but a manufacture of a polymer may become disadvantageous economically, and the water solubility of a polymer may fall has the scale prevention effect.

[0006] Although there is especially no limit in the molecular weight of the water-soluble polymer which has the silanol-group unit used for this invention, usually, it is desirable that it is 500-100,000 as weight average molecular weight, it is more desirable that it is 3,000-70,000, and it is still desirable that it is 10,000-50,000. When the weight average molecular weight of a water-soluble polymer is less than 500, there is a possibility that the scale prevention effect may not fully be demonstrated. When the weight average molecular weight of a water-soluble polymer exceeds 100,000, there is a possibility that the viscosity of the aqueous solution of a polymer may become high too much, and handling may become difficult. The molecular weight of a polymer can be calculated by the gel permeation chromatography, the light scattering measurement, etc. The monomer which has the base which especially a limit does not have in the manufacture technique of a water-soluble polymer of having the silanol-group unit used for this invention, for example, turns into a silanol group by hydrolysis, The monomer which has the base which can manufacture by understanding the obtained copolymer an added water part after copolymerizing the monomer which has the base which turns into a hydrophilic radical by hydrolysis, and turns into a silanol group by hydrolysis, After copolymerizing the monomer which has a hydrophilic radical, it can manufacture by carrying out copolymerization of the monomer which can manufacture by understanding the obtained copolymer an added water part, or has a silanol group, and the monomer which has a hydrophilic radical.

[0007] As a monomer which has the base which turns into a silanol group by hydrolysis, vinyltrimetoxysilane, vinyltriethoxysilane, \*\*\*\*\* propoxysilane, vinyl \*\*\*\*\*

propoxysilane, a vinyl tris (2-methoxyethoxy) silane, etc. can be mentioned, for example. These monomers can be manufactured by the addition reaction of trialkoxysilane and acetylene, or the reaction of a vinyl trichlorosilane and alcohol. As a monomer which has the base which turns into a hydrophilic radical by hydrolysis, acrylonitrile (meta), methyl (meta) acrylate, ethyl (meta) acrylate, vinyl acetate, a maleic anhydride, N-alkyl (meta) acrylamide, etc. can be mentioned, for example. As a monomer which has a hydrophilic radical, an acrylic acid (meta), a maleic acid, an itaconic acid, a vinyl sulfonic acid, an allyl-compound sulfonic acid, a 2-acrylamide-isobutane sulfonic acid, a 3-ant \*\*\*\*\*-2-hydroxy propane sulfonic acid, a styrene sulfonic acid, isoprene sulfonic acids or these alkali-metal salts, hydroxyethyl (meta) acrylate, \*\*\*\*\* monoallyl ether, allyl alcohol, an acrylamide (meta), N-vinyl pyrrolidone, etc. can be mentioned, for example. The water-soluble polymer used for this invention is the domain which does not lose the water solubility, and can have a hydrophobic monomeric unit. As such a hydrophobic monomer, styrene, N-vinylcarbazole, etc. can be mentioned, for example.

[0008] The monomer which has the monomer or silanol group which has the base which turns into a silanol group by hydrolysis used for this invention, There is especially no limit in the copolymerization technique with the monomer which has the monomer or hydrophilic radical which has the base which turns into a hydrophilic radical by hydrolysis, and if all monomers and copolymers obtained are water-soluble The solution polymerization through water can be performed, and if the copolymer obtained with the monomer of all or a part is water-insoluble nature, the emulsion polymerization or suspension polymerization through water, and the solution polymerization through an organic solvent can be performed. The copolymer of the monomer which has the base which turns into a hydrophilic radical by the monomer or hydrolysis which has the base which turns into a silanol group by hydrolysis is changed into the water-soluble polymer which has the silanol group and hydrophilic radical which are expressed with a general formula [1] by hydrolysis. There is especially no limit in the hydrolysis technique, and it can understand an added water part in an aqueous medium preferably using an acid, alkali, etc. With [ the carbon number of an alkoxyl group ] three [ or less ], let the copolymer of vinyl trialkoxysilane be the silanol-group unit shown by the general formula [1] by understanding 1 of three alkoxyl groups, two pieces, or three pieces an added water part. Moreover, with [ the carbon number of an alkoxyl group ] four [ or more ], in a general formula [1], it can consider as the silanol-group unit R1 and whose R2 are hydrogen by understanding all alkoxyl groups an added water part. When the monomer which has the base which turns into a hydrophilic radical by hydrolysis is vinyl acetate, a vinyl acetate unit is changed per vinyl alcohol by hydrolysis, and a polymer becomes water-soluble. [0009] The scale inhibitor of this invention can be used with respect to water quality conditions and \*\*\*\*\*s, such as a cooling water system and the boiler water system, that there is nothing. The scale inhibitor of this invention can be added and used for circulating water or make up water in a cooling water system, the boiler water system, etc. There is especially no limit in the location and the addition technique of adding the scale inhibitor of this invention, and it can be added in arbitrary parts as aqueous solution prepared to arbitrary concentration in the drainage system to use to them. Although the addition of the scale inhibitor of this invention can be suitably chosen according to the water quality of the drainage system to add, the service condition of a facility, etc., it is desirable to add so that underwater concentration may usually become l. in 1-200mg /, and it is more desirable to add so that it may become l. in 10-50mg /. The scale inhibitor of this invention can be used together with other scale inhibitors, anticorrosives, a germicide, a slime inhibitor, etc. if needed. When using the scale inhibitor of this invention together with other medicines, the medicine of \*\*\*\*\* can be

mixed beforehand, and it can consider as a 1 liquid type, or each can be added separately. While adhesion in the heating surface and the piping wall surface of scales, such as a calcium carbonate, a calcium sulfate, calcium phosphate, phosphoric-acid zinc, zinc hydroxide, a magnesium silicate, and a silica, which occur in a cooling water system, the boiler water system, etc. can be prevented by the scale inhibitor of this invention, the scale which already adhered is also removable. Especially the scale inhibitor of this invention demonstrates the effect excellent in scale-buildup prevention of a silicic-acid system. Although the detailed mechanism of action of the scale inhibitor of this invention is unknown, it is thought by combining with the colloidal silica which is the scale formation factor which a polymer generates by the drainage system through a silanol group that the adhesion to the system wall of a silicic-acid system scale etc. is prevented effectively.

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## EXAMPLE

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[Example] Although an example is given to below and this invention is explained to it still in detail, this invention is not limited at all by these examples. The scale inhibitor and scaling test method which were used for the example and the example of a comparison are shown below.  
[Scale inhibitor]

(A) The vinyl silanol / vinyl alcohol copolymer, molecular weight 15,000 which were obtained by understanding a copolymer (vinyltrimetoxysilane 2 mol % and 98 mols % of vinyl acetate) an added water part.

(B) The vinyl silanol / vinyl alcohol / allyl alcohol copolymer, molecular weight 15,000 which were obtained by understanding the 88 mols copolymer (% and allyl alcohol 10 mol %) of vinyl acetate an added water part vinyltrimetoxysilane 2 mol%.

(C) The vinyl silanol / vinyl alcohol / styrene copolymer, molecular weight 15,000 which were obtained by understanding the 90 mols copolymer (% and styrene 5 mol %) of vinyl acetate an added water part vinyltrimetoxysilane 5 mol%.

(D) A copolymer (80 mols % of acrylic acids, and 20 mols % of 3-ant \*\*\*\*\*-2-hydroxy propane sulfonic acids), molecular weight 9,000.

the possession in which a [scaling test-method] heating surface has the heat exchanger of 2 about 0.25m -- 0.45m of amount of water, the water which added salts was added to the pure water or the Atsugi city water as circulating water and make up water at the open circulating model cooling water system of 3, and it ran continuously for 30 days, controlling blow water so that a concentration multiple becomes 5 times The quality of the material used for the heat exchanger the tube whose outer diameter is 19mm by SUS304. The heat exchanger inlet temperature of circulating water adjusted 45 degrees C and heat exchanger outlet temperature to 75 degrees C, and the rate of flow in the tube side of circulating water was carried out in 0.5m/s. In the meantime, the specified quantity of a scale inhibitor was added to the drainage system. After 30 day continuous running, the scale adhering to the heat exchanger tube front face was extracted. Weighing capacity of this scale was carried out, and the scaling speed was computed from the coating weight. Moreover, the chemical analysis of this scale was carried out, and SiO<sub>2</sub> amount in a scale was calculated.

It examined by adding a scale inhibitor (A) so that it may become [ 1. ] in 20mg /in the water which has water quality with silica 200mg/a l. [ an example 1pH /9.0 /, a calcium-hardness of 0mg //l. /, 0mg //l. / M alkalinity, ], and a magnesium degree of hardness of 200mg [/l. ]. Scaling

speeds will be 8mg/[cm]<sup>2</sup>/30 days, and SiO<sub>2</sub> was not contained in the scale.

In the same water of water quality as example 2 example 1, it examined by adding a scale inhibitor (B) so that it may become [ 1. ] in 20mg /. Scaling speeds will be 10mg/[cm]<sup>2</sup>/30 days, and SiO<sub>2</sub> was not contained in the scale.

In the same water of water quality as example 3 example 1, it examined by adding a scale inhibitor (C) so that it may become [ 1. ] in 20mg /. Scaling speeds were 11mg/[cm]<sup>2</sup>/30 days, and SiO<sub>2</sub> amount in a scale was 1 % of the weight.

In the same water of water quality as example of comparison 1 example 1, it examined by adding a scale inhibitor (D) so that it may become [ 1. ] in 20mg /. Scaling speeds were 111mg/[cm]<sup>2</sup>/30 days, and SiO<sub>2</sub> amount in a scale was 45 % of the weight. The result of the examples 1-3 and the example 1 of a comparison is shown in the 1st table.

[0011]

[Table 1]

第1表

	スケール防止剤	添加量 (mg/リットル)	スケール付着速度 (mg/cm <sup>2</sup> /30日)	スケール中のSiO <sub>2</sub> 量 (重量%)
実施例1	(A)	20	8	0
実施例2	(B)	20	10	0
実施例3	(C)	20	11	1
比較例1	(D)	20	111	45

[0012] In the examples 1-3 which added the scale inhibitor of this invention, a scaling speed is small, there are very few SiO<sub>2</sub> amounts in a scale, the scale inhibitor of this invention has the large scaling prevention effect, and the result of the 1st table shows excelling especially in the antisticking of SiO<sub>2</sub>. On the other hand, in the example 1 of a comparison which added the conventional scale inhibitor, a scaling speed is large and there are also many amounts of SiO<sub>2</sub> in a scale.

It examined by adding a scale inhibitor (A) so that it may become [ 1. ] in 20mg /in the water which has water quality with silica 200mg/a l. [ an example 4pH /9.0 /, a calcium hardness of 500mg //l. /, 500mg //l. / M alkalinity, ], and a magnesium degree of hardness of 200mg [/l. ]. Scaling speeds will be 8mg/[cm]<sup>2</sup>/30 days, and SiO<sub>2</sub> was not contained in the scale.

In the same water of water quality as example 5 example 4, it examined by adding a scale inhibitor (B) so that it may become [ 1. ] in 20mg /. Scaling speeds were 8mg/[cm]<sup>2</sup>/30 days, and SiO<sub>2</sub> amount in a scale was 1 % of the weight.

In the same water of water quality as example 6 example 4, it examined by adding a scale inhibitor (C) so that it may become [ 1. ] in 20mg /. Scaling speeds were 14mg/[cm]<sup>2</sup>/30 days, and SiO<sub>2</sub> amount in a scale was 1 % of the weight.

In the same water of water quality as example of comparison 2 example 4, it examined by adding a scale inhibitor (D) so that it may become [ 1. ] in 20mg /. Scaling speeds were 124mg/[cm]<sup>2</sup>/30 days, and SiO<sub>2</sub> amount in a scale was 52 % of the weight.

In the same water of water quality as example of comparison 3 example 4, it examined by adding a scale inhibitor (D) so that it may become [ 1. ] in 40mg /. Scaling speeds were 119mg/[cm]<sup>2</sup>/30 days, and SiO<sub>2</sub> amount in a scale was 47 % of the weight. The result of the examples 4-6 and the examples 2-3 of a comparison is shown in the 2nd table.

[0013]

[Table 2]  
第2表

	スケール防止剤	添加量 (mg/リットル)	スケール付着速度 (mg/cm <sup>2</sup> /30日)	スケール中のSiO <sub>2</sub> 量 (重量%)
実施例4	(A)	20	8	0
実施例5	(B)	20	8	1
実施例6	(C)	20	14	1
比較例2	(D)	20	124	52
比較例3	(D)	40	119	47

[0014] In the examples 4-6 which added the scale inhibitor of this invention, a scaling speed is small, there are few SiO<sub>2</sub> amounts in a scale, the scale inhibitor of this invention has the large scaling prevention effect, and the result of the 2nd table shows excelling especially in the antisticking of SiO<sub>2</sub>. On the other hand, in the example 2 of a comparison which added the conventional scale inhibitor, a scaling speed is large and there are also many amounts of SiO<sub>2</sub> in a scale. Furthermore, in the example 3 of a comparison, although the addition of the same conventional scale inhibitor as the example 2 of a comparison is doubled, the enhancement in the scale prevention effect is very slight.

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[Translation done.]